# The Ohio Naturalist,

PUBLISHED BY

*The Biological Club of the Ohio State University.*

Volume XII. DECEMBER, 1911. No. 2.

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## THE CLASSIFICATION OF PLANTS, VII.[1]

JOHN H. SCHAFFNER.

There can be little question as to the general importance of a correct taxonomy; for the views of all botanists, whether they deal directly with classification or not, must be more or less influenced by the scheme of supposed relationships which they follow. On the arrangement accepted must depend one's ideas of what are high and low plants, and this again must have its effect on one's views about derivation and evolution. Thus one finds the arguments advanced by various authors based very largely on the classification followed. The viewpoint must certainly be fundimentally different when, on the one hand, primitive forms are recognized in such remarkably specialized trees as Casuarina, or, on the other, in a general type like Magnolia.

Ecological adaptations must be explained on the same basis. One must determine whether anemophilous and hydrophilous flowering plants are the more primitive or those that are entomophilous; whether the bisporangiate or monosporangiate flowers represent the original type; whether vestigial organs are to be regarded as being derived from normal ones and thus as indicating lines of evolution.

When a correct series is established, there is often a remarkable parallelism between the evolutionary development and specialization of the flower and the completeness of the ecological adaptation. Thus in the lowest Alismales the plants are aerial with showy bisporangiate flowers having numerous parts in spirals and usually possessing nectar glands, while the most specialized species are completely aquatic with reduced monecious or diecious flowers without perianth and with hydrophilous pollination.

1. Contributions from the Botanical Laboratory of Ohio State University, 64.

Such a sequence can be traced more or less completely in other hydrophytic groups.

Anemophily has also been developed independently in numerous groups; nearly always accompanied by the monosporangiate condition, loss of part or all of the perianth, and general reduction of the flower and the inflorescence.

Peculiar morphological conceptions of development are frequently formulated on the basis of an improper taxonomy, and transformations and re-creations are either tacitly or openly advocated, the acceptance of which would require a credulity greater than a belief in an innumerable series of special creations. Even the interpretation of the geological history of plants depends somewhat on our scheme of classification; since the geological history of plants, so far deciphered, is exceedingly incomplete and must still be interpreted through the morphology of living species.

Three general systems of plant classification have been in vogue: (1) the artificial system, (2) the so-called natural system, and (3) the phyletic or evolutionary system. For the larger groups, the old natural system is still largely in use, and in the detailed arrangements of genera and species, one can still detect much of the artificial method. The natural system was not based on evolutionary principles, and probably prevented many of its followers from accepting the doctrine of descent because of the impossible transformations which would have been required to obtain genetic continuity in the series of plant forms expressed in the classifications of the time.

To reconstruct classification on a phyletic basis will require much shifting, not only of the larger phyla and classes but also of orders, families, genera, and species. But we may safely formulate a principle of procedure which, although not always giving final results at present, will eventually lead to a true "natural" classification and will give us a more or less reliable presentation of the evolutionary history of the plant kingdom.

In tracing derivative relationships between two groups of plants, one of the essential considerations is the possibility of the transformation of the structures of the one into the other. Every morphological structure of the entire organism must be reasonably derived from some ancestral type, and the fact kept constantly in mind that one organ may be evolving or specializing rapidly while another is undergoing little change. In discussions of this nature carried on by those who do not follow the phyletic idea but divide plants arbitrarily by some more or less constant peculiarity, which may or may not indicate relationship, the result often becomes so artificial that whole groups of normal organs are derived bodily from the most extreme vestiges. So long as we do not see the course of evolution proceeding from vestigial

to normal organs it is not necessary to give much weight to such results. In the higher plants vestiges are exceedingly abundant and give a plain index to the course of phylogenetic development. Derivations or supposed relationships are also frequently based on *assumptions* from isolated morphological peculiarities which can be explained equally well on other *assumptions* that will not require the complete re-creation of the species from its supposed ancestor.

The basis of a modern taxonomy must at all events include the following principles:

1. The comparative study of the organography and anatomy of plants, proceeding from the simple to the more complex.
2. The definite recognition of primordia and transformations on the one hand and of vestiges on the other.
3. A study of incepts, embryological developments and juvenile forms.
4. The investigation of lines of degeneration and specialization, in both low and high types, leading from complex to simple structures.
5. The segregation of the units into genetically or phylogenetically related groups.
6. The arrangement of the branches thus segregated into series extending from the lowest and least differentiated to the most highly specialized.
7. In a word, the whole scheme of classification must show the result which has come about through progressive evolution, segregation, degredation, and specialization.

In the sixth article of this series of papers, an arrangement of the orders and families of Anthophyta found in the Northeastern United States was given. Since then the scheme has undergone some slight change in the writer's hands. It is believed that after this no important changes need be made for some time except perhaps the transfer of a few families after a wider knowledge of them is gained. The changes are as follows:

Transfer the Limnanthaceae to the Geraniales following the Oxalidaceae.

Interchange the subfamilies Melanthatae and Liliatae, placing the latter as the lowest group of the Liliaceae.

Divide the Hydrangeaceae into two subfamilies, Philadelphatae and Hydrangeatae.

Following the order, Saxifragales, insert the order Thymeleales including in sequence the families, Lythraceae, Thymeleaceae, Elaeagnaceae.

A preliminary synopsis is now given of the subclasses and orders of the Anthophyta. It is hoped that this may present a better view of the phyletic classification as applied to the higher plants and stimulate to further study.

The Alismales and Ranales lead in the two classes, Monocotylae and Dicotylae. The Helobiae do not represent the most primitive leaf and stem arrangements because of numerous hydrophytic adaptations. These adaptations are, however, direct modifications of primitive types. But the flowers in the lowest Alisimales and Nymphaeales are by far the most primitive to be found among Monocotyls. However, the frequent dichotomous venation of certain species is very suggestive of primitive seed plants and ferns. The more primitive leaf and stem arrangements to be found among the Monocotyls are preserved in such groups as the palms, screw-pines and yuccas.

Following the synopses, a complete classification is given of the phyla, classes and subclasses, with a slight improvement over the schemes published in former papers.

SYNOPSIS OF THE SUBCLASSES AND ORDERS OF ANTHOPHYTA.

## HELOBIAE.

Usually aquatic or marsh herbs with hypogynous or epigynous, actinomorphic, spiral or cyclic, bisporangiate or monosporangiate flowers; flowers solitary, axillary, racemose, or occasionally closely clustered; perianth frequently with prominent corolla, sometimes undifferentiated, vestigial or absent; carpels in the lower forms numerous and free, in the higher few and united; sperms in the pollengrain two.

*Synopsis.*

I. Flowers hypogynous or somewhat perigynous; carpels free or united, spiral or cyclic.
   1. Plants normal, with chlorophyll.
      a. Hypocotyledonary expansion, if present not lobed or only slightly notched; ovules usually anatropous or campylotropous; leaves often narrow, not peltate and not with a narrow basal sinus but sometimes sagitate, or deeply cordate. **Alismales.**
      b. Hypocotyledonary expansion parted into two lobes or deeply notched; ovules orthotropous; aerial or floating leaves peltate, with a deep basal sinus, or if somewhat sagitate then with carpels numerous and united. **Nymphaeales.**
   2. Small yellowish or reddish phagophytes. **Triuridales.**

II. Flowers epigynous; carpels united, cyclic. **Hydrocharitales.**

## SPADICIFLORAE.

Trees, herbs, or climbing plants, usually with clustered flowers; the inflorescence being a crowded panicle, spike or spadix, rarely reduced; flowers hypogynous, often monosporangiate, the perianth present or absent, not definitely differentiated into calyx and corolla and commonly inconspicuous; carpels 4–1, usually 3, free or united.

*Synopsis.*

I. Inflorescence not a typical spadix.
  1. Leaves usually plicate and more or less split at maturity.
    a. Carpels free or united, usually 3, forming a unilocular or plurilocular ovulary with one ovule for each carpel. **Palmales.**
    b. Carpels united; ovulary unilocular with numerous seeds on 2 or 4 parietal placentae. **Cyclanthales.**
  2. Leaves linear or sword-shaped, not plicate and not splitting at maturity; flowers monecious, spikate or capitate. **Pandanales.**

II. Inflorescence a fleshy spadix, with or without a spathe; or minute plants without leaves floating free, the flowers few or solitary on the modified stem. **Arales.**

## GLUMIFLORAE.

Usually grass-like herbs or rarely woody plants with hypogynous, inconspicuous flowers; carpels united, with 3–1 stigmas; perianth of 6–2 chaffy segments, or none; inflorescence usually consisting of spikelets or spikes; endosperm mealy or starchy.

*Synopsis.*

I. Ovulary 3–1–locular; ovules solitary in the cavities, orthotropous, pendulous. **Restionales.**

II. Ovulary unilocular, 1–ovuled, ovules anatropous, erect or ascending. **Graminales.**

## LILIIFLORAE.

Herbs, sometimes shrubs, lianas or trees, usually with prominent flowers, with showy petals or staminodes, hypogynous or epigynous, solitary or clustered; carpels 3 or sometimes 2, united; flowers pentacyclic and trimerous or some modification of this type, usually bisporangiate but occasionally monecious or diecious, actinomorphic in the lower and prominently zygomorphic in the higher types; endosperm mealy, fleshy, or horny, sometimes none.

*Synopsis.*

I. Flowers hypogynous, seeds with endosperm. **Liliales.**

II. Flowers partly or completely epigynous.
  1. Seeds with endosperm.
    a. Flowers mostly regular. **Iridales.**
    b. Flowers very irregular, usually zygomorphic. **Scitaminales.**
  2. Seeds without endosperm, very numerous and minute; flowers usually irregular and zygomorphic. **Orchidales.**

## THALAMIFLORAE.

Herbs or woody plants with hypogynous, choripetalous or apetalous flowers, calyx commonly of distinct sepals and inserted, with the other parts of the flower, directly on the floral axis.

*Synopsis.*

I. Carpels many to one, spiral or cyclic, usually free or only slightly united; stamens usually numerous. **Ranales.**

II. Carpels more or less united, cyclic.

1. Herbs with insectivorous leaves; carpels 5–3. **Sarraceniales.**
2. Herbs or woody plants with normal leaves, not insectivorous.
   a. Carpels 2 or more with parietal placentae; perianth usually with an even number of segments, the flowers commonly isobilateral. **Brassicales.**
   b. Carpels mostly 5 or 3; stamens mostly 10 or 5, or a reduction from 10; ovules pendulous. **Geraniales.**
   c. Carpels many to 3, ovules few; stamens indefinite, monadelphous, branched or clustered, or by reduction separate and few; sepals valvate. **Malvales.**
   d. Carpels 2 or more, commonly with parietal placentae; stamens usually indefinite; sepals and petals usually 5, sepals imbricated or convolute. **Guttiferales.**

## CENTROSPERMAE.

Mostly herbaceous plants with hypogynous syncarpous flowers; usually apetalous except in the lowest families; ovulary usually with a central basal ovule or with many ovules on a central placenta.

*Synopsis.*

I. Perianth present consisting of a calyx and corolla or of a calyx only.

1. Embryo curved, coiled, or annular, fruit not an achene.
   a. Fruit a capsule, berry, or anthocarp; calyx present; corolla present or absent. **Caryophyllales.**
   b. Fruit a utricle; calyx present, corolla none. **Chenopodiales.**
2. Embryo straight or nearly so; fruit an achene. **Polygonales.**

II. Perianth none or vestigial; ovules usually orthotropous. **Piperales.**

## CALYCIFLORAE.

Perianth and stamens usually borne on a perigynous disk or hypanthium which is sometimes united with the ovulary; carpels free or united; calyx usually of united sepals, petals when present separate.

*Synopsis.*

I. Carpels free or united, spiral or cyclic.
  1. Endosperm usually little or none; leaves mostly with stipules; carpels spiral or cyclic, often reduced to one, usually free or only slightly united, with a few evident exceptions. **Rosales.**
  2. Endosperm present and usually copious; leaves usually without stipules; carpels cyclic, free or united, sometimes slightly epigynous. **Saxifragales.**

II. Carpels united, cyclic.
  1. Hypanthium tubular or urn-shaped, often constricted above and enclosing the ripe fruit; endosperm commonly little or none. **Thymeleales.**
  2. Receptacle developing a glandular, annular, or turgid disk which is somewhat united with the perianth or ovulary, endosperm present or none. **Celastrales.**
  3. Disk tumid, united with the perianth, sometimes reduced; endosperm usually none. **Sapindales.**

## AMENTIFERAE.

Mostly trees or shrubs with hypogynous or perigynous flowers, commonly in aments or ament-like clusters; flowers mostly apetalous or naked, generally monecious or diecious.

*Synopsis.*

I. Flowers not in typical aments, often in pendant heads or ament-like spikes or clusters; usually monosporangiate.
  1. Leaves alternate or rarely opposite.
    a. Stamens alternate with the petals (when present), or numerous; perianth sometimes none. **Platanales.**
    b. Stamens mostly 4, opposite the usually 4 sepals.
      (a) Calyx not petaloid. **Urticales.**
      (b) Calyx petaloid; stamens usually united with the sepals. **Proteales.**
  2. Leaves whorled, reduced to scales, ovulary unilocular with two ovules. **Casuarinales.**

II. Flowers, at least the staminate ones, in aments, monosporangiate.
  1. Seeds not with a tuft of hairs, fruit a typical or modified nut, achene or samara; plants monecious or diecious.
    a. Fruit 2–or more–seeded, ovules with 1 integument. **Balanopsidales.**
    b. Fruit usually 1 seeded. **Fagales.**
  2. Seeds with a tuft of hairs at one end; several in the capsule; flowers diecious without perianth; leaves usually alternate. **Salicales.**

## MYRTIFLORAE.

Epigynous plants usually with large showy flowers, with or without a prominent hypanthium; more commonly choripetalous, but sometimes sympetalous or completely apetalous; ovules commonly numerous.

*Synopsis.*

I. Fleshy usually prickly and spiny plants with jointed stems and reduced leaves; perianth segments usually very numerous. **Cactales.**

II. Herbs, shrubs or trees not spiny like the preceding; calyx-segments rarely more than 5.

1. Petals usually present, choripetalous; sometimes apetalous or sympetalous.
   a. Flowers usually bisporangiate, placentae usually axile or apical, rarely basal. **Myrtales.**
   b. Flowers bisporangiate or monosporangiate; placentae usually parietal; mostly herbs or herbaceous vines. **Loasales.**
2. Petals usually absent; if present either choripetalous or sympetalous.
   a. Ovulary with several cavities, usually 6-locular; herbs or vines. **Aristolochiales.**
   b. Ovulary unilocular; mostly parasitic herbs or shrubs. **Santalales.**

## HETEROMERAE.

Low, often evergreen, shrubs, trees, or herbs usually with hypogynous flowers which are usually sympetalous but sometimes choripetalous; perianth usually regular or nearly so inserted on the floral axis; stamens united with the corolla or free, usually as many or twice as many as the corolla-lobes; carpels usually 5–3.

*Synopsis.*

I. Ovulary mostly unilocular and usually with a free central placenta; stamens opposite the petals or more numerous, united with the corolla, mostly herbs. **Primulales.**

II. Ovulary mostly 2–or more locular or with parietal placentae; herbs, shrubs, or trees.

1. Stamens mostly free from the corolla, alternate with its lobes or twice as many; seeds minute; flowers bisporangiate, hypogynous, sometimes choripetalous. **Ericales.**
2. Stamens united with the corolla, opposite its lobes or twice as many or more; seeds usually solitary or few, usually large; flowers hypogynous or sometimes epigynous, sometimes choripetalous. **Ebenales.**

## TUBIFLORAE.

Herbs, shrubs, or trees with hypogynous, sympetalous, occasionally choripetalous or apetalous flowers; flowers normally tetracyclic, usually with two united carpels; stamens united with the corolla, as many as its lobes and alternate, or fewer.

*Synopsis.*

I. Corolla not scarious, nerved.
  1. Fruit usually a capsule, follicle, berry, drupe, or samara; carpels commonly several-to-many-seeded.
    a. Corolla regular; stamens usually of the same number as the corolla lobes.
      (a) Leaves alternate or opposite; ovularies not separating. **Polemoniales.**
      (b) Leaves usually opposite; ovularies frequently separating below, with a common style; if not separating, usually with two cavities or two placentae. **Gentianales.**
    b. Corolla mostly irregular or oblique; fertile stamens commonly fewer than the corolla lobes. **Scrophulariales.**
  2. Fruit indehiscent but usually splitting and forming 4 nutlets around the style; carpels 1–2–seeded. **Lamiales.**

II. Corolla usually scarious, nerveless; calyx and corolla 4-lobed. **Plantaginales.**

## INFERAE.

Mostly herbs, occasionally shrubs, trees, or lianas, with epigynous, choripetalous or sympetalous, or rarely apetalous flowers; stamens usually as many as the petals or corolla lobes and alternate with them; carpels two or more, united; calyx often vestigial.

*Synopsis.*

I. Anthers separate.
  1. Corolla choripetalous; flowers usually in umbels or cymes. **Umbellales.**
  2. Corolla sympetalous. **Rubiales.**

II. Anthers, with few exceptions, united; corolla sympetalous.
  1. Flowers not in involucrate heads. **Campanulales.**
  2. Flowers in dense involucrate heads; gynecium of two, or rarely three, united carpels, unilocular; seed one. **Compositales.**

### Phyla, Classes, and Subclasses of Plants.

Phylum I. SCHIZOPHYTA. Fission Plants.
  Class 1. Cyanophyceae. Blue-green Algae.
  Class 2. Glaucocysteae.
  Class 3. Schizomycetae. Fission Fungi.
  Class 4. Myxoschizomycetae. Slime Bactera.

Phylum II. MYXOPHYTA. Slime Molds.
Class 5. Plasmodiophoreae. (?)
Class 6. Myxomycetae.
Subclasses, Acrasieae.
Myxogastreae.

Phylum III. ZYGOPHYTA. Conjugate Algae.
Class 7. Diatomeae. Diatoms.
Class 8. Conjugatae.

Phylum IV. GONIDIOPHYTA. Zoospore Plants.
Class 9. Pleurococceae.
Class 10. Protococceae.
Class 11. Archemycetae.
Class 12. Hydrodictyeae.
Class 13. Monoblepharideae.
Class 14. Siphoneae. Tube Algae.
Class 15. Conferveae.

Phylum V. PHAEOPHYTA. Brown Algae.
Class 16. Phaeosporeae.
Class 17. Cyclosporeae.
Class 18. Dictyoteae.

Phylum VI. RHODOPHYTA. Red Algae.
Class 19. Bangieae.
Class 20. Florideae.

Phylum VII. CHAROPHYTA. Stoneworts.
Class 21. Chareae.

Phylum VIII. MYCOPHYTA. Higher Fungi.
Class 22. Zygomycetae.
Class 23. Oomycetae.
Class 24. Ascomycetae. Sack Fungi.
Subclasses, Hemiascae. Intermediate Sack Fungi.
Aspergilleae. Tuber Fungi.
Discomycetae.
Discolichenes.
Pyrenomycetae.
Pyrenolichenes.
Exoascae.
Deuteromycetae. Imperfect Fungi.
Class 25. Laboulbenieae. Beetle Fungi.
Class 26. Teliosporeae. Brand Fungi.
Class 27. Basidiomycetae. Basidium Fungi.
Subclasses, Protobasidiae.
Hymenomycetae.
Hymenolichenes.
Gastromycetae.

Phylum IX. BRYOPHYTA. Mossworts.
- Class 28. Hepaticae. Liverworts.
- Class 29. Sphagneae. Bogmosses.
- Class 30. Andreaeae. Granite Mosses.
- Class 31. Musci. True Mosses.
- Class 32. Anthoceroteae. Hornworts.

Phylum X. PTENOPHYTA. Fernworts.
- Class 33. Filices. Ferns.
  - Subclasses, Eusporangiatae. Primitive Ferns.
  - Leptosporangiatae. Modern Ferns.
- Class 34. Hydropterides. Water-ferns.
- Class 35. Isoeteae. Quillworts.

Phylum XI. CALAMOPHYTA. Horsetails and Allies.
- Class 36. Equiseteae. Horsetails.
- Class 37. Calamariae (Fossil) Calamites.
- Class 38. Sphenophylleae (Fossil) Wedge-leaf Calamites.

Phylum XII. LEPIDOPHYTA. Lycopods and Allies.
- Class 39. Lycopodieae. Lycopods.
- Class 40. Selaginelleae. Selaginellas.

Phyllum XIII. CYCADOPHYTA. Cycads and Allies.
- Class 41. Pteridospermae (Fossil) Seed Ferns.
- Class 42. Cycadeae. Cycads.
- Class 43. Cordaiteae (Fossil). Cordaites.
- Class 44. Ginkgoeae. Maiden-hair-trees.

Phylum XIV. STROBILOPHYTA. Conifers and Allies.
- Class 45. Coniferae. Conifers.
- Class 46. Gneteae. Joint-firs.

Phylum XV. ANTHOPHYTA. Flowering Plants.
- Class 47. Monocotylae. Monocotyls.
  - Subclasses, Helobiae.
  - Spadiciflorae.
  - Glumiflorae.
  - Liliiflorae.
- Class 48. Dicotylae. Dicotyls.
  - Subclasses, Thalamiflorae.
  - Centrospermae.
  - Calyciflorae.
  - Amentiferae.
  - Myrtiflorae.
  - Heteromerae.
  - Tubiflorae.
  - Inferae.